Table 3-29. Hospital use by county in the region of influence.[a]

County	1995[b]	1998	2000
Clark			
Population	1,000,000	1,260,000[c]	1,380,000[d]
Average number of beds	2,100	2,400[e]	2,600[f,g,h]
Beds per 1,000 residents	2.2	1.9[f]	1.9[e]
Patient-days	530,000	607,000[c]	N/A
Nye			
Population	24,000	29,700[c]	32,000[d]
Average number of beds	21	10[e]	42[f,g]
Beds per 1,000 residents	0.86	0.33[f]	1.3
Patient-days	1,900	560[e]	N/A
Lincoln			
Population	3,900	4,200[c]	4,200[d]
Average number of beds	4	4[e]	20[f,g]
Beds per 1,000 residents	1.0	0.95[f]	4.8
Patient-days	360	300[e]	N/A

a. All displayed numbers have been rounded to two or three significant figures.
b. Source: DIRS 103451-Rodefer et al. (1996, pp. 214 to 216).
c. Source: DIRS 153928-NDA (2000, all).
d. Source: DIRS 155872-Bureau of the Census (2000, County totals).
e. Average number of beds and patient days (DIRS 155910-State of Nevada 1999, all).
f. DIRS 156286-Medical Central Online (2001, all).
g. Actual, staffed number of beds.
h. DIRS 156288-Babula (2001, all).

Protection. A combination of fire departments provides protection in the region of influence; these include the Clark County, Las Vegas, and North Las Vegas fire departments and several other city, county, and military departments. In 2001, the Clark County Fire Department had about 500 paid and 390 volunteer firefighters. The Las Vegas Fire Department had 334 paid firefighters and the North Las Vegas Fire Department had 259 firefighters. In 2001, Nye County and Lincoln County met fire suppression needs with volunteers from the individual communities in the counties. The national average is 4.1 firefighters (paid and volunteer) per 1,000 residents.

3.1.8 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

The public health and safety region of influence consists of the number of persons residing within an 80-kilometer (50-mile) radius of the repository site at the end of site characterization. The estimated population in 2000 is about 34,000, which could grow to an estimated 76,000 by 2035. Both the population estimate for 2000 and the projection for 2035 are based on the State Demographer and Local Agencies' Baseline as described in Section 3.1.7, and are distributed over the 80-kilometer (50-mile) radius as shown in Figure 3-25. The region of influence includes parts of Nye, Clark, Lincoln, and Esmeralda Counties in Nevada, as well as Inyo County in California (Figure 3-25). Potentially affected workers include those at the repository site and at nearby Nevada Test Site facilities. This section describes the existing radiation environment and the baseline cancer incidence in the region of influence. Unless otherwise noted, the *Environmental Baseline File for Human Health* (DIRS 104544-CRWMS M&O 1999, all) is the basis of the information in this section.

Section 3.1.8.1 describes the various radiation sources that make up the radiation environment. Section 3.1.8.2 describes the existing radiation environment in the Yucca Mountain region. Section 3.1.8.3 describes the health-related mineral issues encountered during site characterization activities. Section 3.1.8.4 describes the worker industrial safety experienced from site characterization activities.

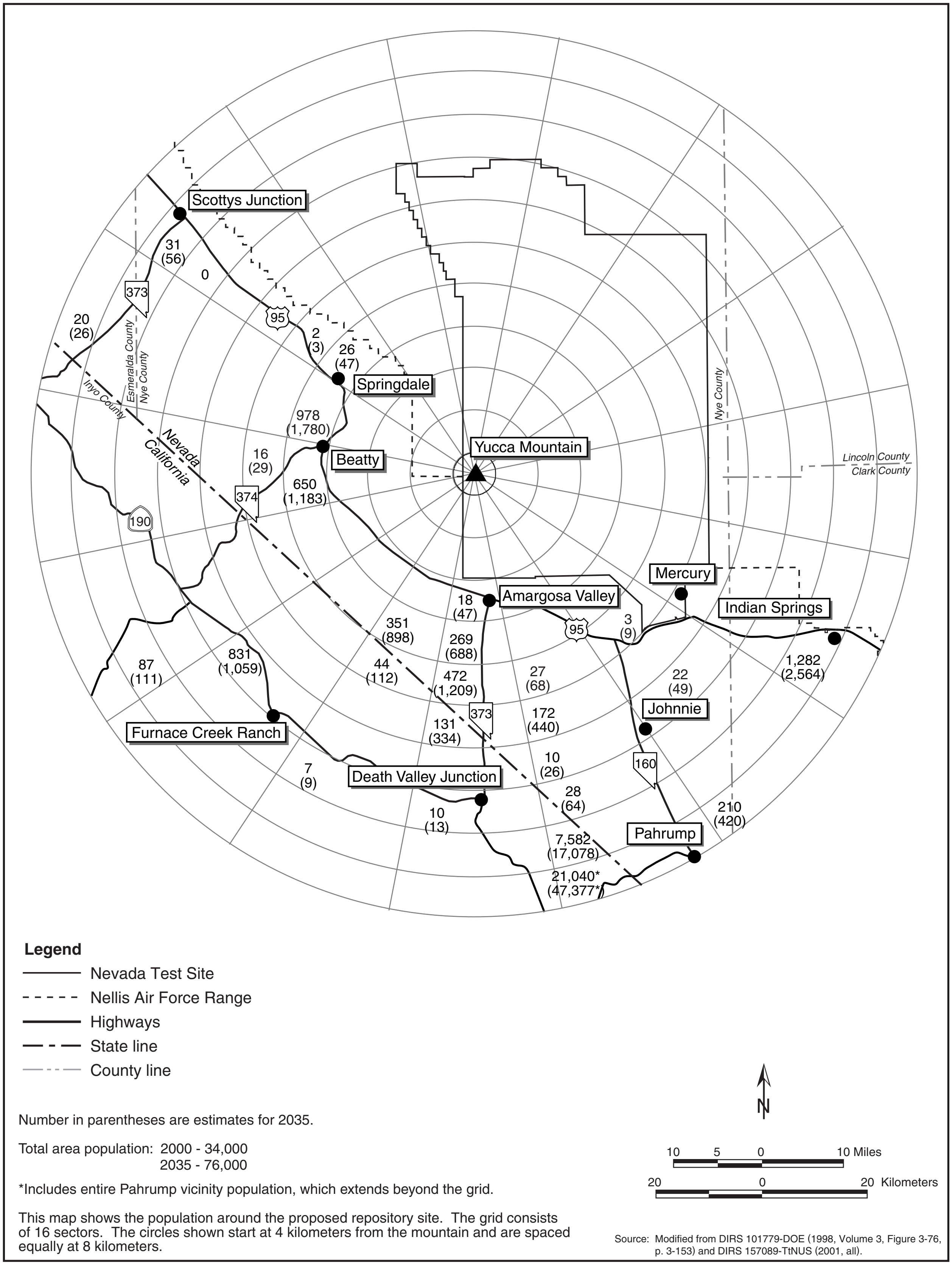

Figure 3-25. Population distribution within 80 kilometers (50 miles) of the proposed repository site, 2000 estimate and 2035 projection (in parentheses), based on the State Demographer and Local Agencies' Baseline.

3.1.8.1 Radiation Sources in the Environment

Types of Radiation. There are ambient levels of radiation at and around the site of the proposed repository just as there are around the world. All people are inevitably exposed to the three sources of *ionizing radiation*: those of *natural* origin unaffected by human activities, those of natural origin but affected by human activities (called *enhanced natural* sources), and *manmade* sources. Natural sources (natural background radiation) include *cosmic radiation* from space, *cosmogenic radionuclides* produced when cosmic radiation interacts with matter in the atmosphere or ground, and naturally occurring, long-lived primordial radionuclides in the Earth's mantle. Enhanced natural sources include those that can increase exposure as a result of human actions, deliberate or otherwise. For example, a mill tailings pile from a uranium extraction process probably would contain concentrated levels of naturally occurring radionuclides. A variety of radiation exposures, generally smaller than those caused by natural sources, result from manmade sources including nuclear medicine, medical *X-rays*, and consumer products.

Natural background radiation is the largest contributor to the average radiation dose of individuals. The natural occurrence of cosmic radiation, cosmogenic radionuclides, and primordial radionuclides varies throughout the world depending on such factors as altitude and geology. External radiation comes from all three of these natural sources, but cosmic radiation and radiation from primordial radionuclides are the largest dose contributors. Cosmic radiation consists of charged particles (primarily protons from extraterrestrial sources) that have sufficiently high energies to generate secondary particles that have direct and indirect ionizing properties. The three main primordial radionuclide contributors to external terrestrial gamma radiation are potassium-40 and the members of the thorium and uranium decay series. Most external terrestrial gamma radiation comes from the top 20 centimeters (8 inches) of soil, with a small contribution from airborne radon decay products. Although of smaller importance to natural external dose than the other two mechanisms, two cosmogenic radionuclides, sodium-22 and beryllium-7, produce quantifiable external doses in humans.

Internal radiation dose from natural sources comes primarily from the primordial radionuclides and their decay products. The largest individual source of internal dose comes from the inhalation of radon-222 and its decay products, which are all members of the uranium-238 decay series. This exposure comes mainly from inhalation of these radionuclides in indoor air, coming from the soil underneath buildings. All of the primordial radionuclides are in the body in various concentrations, incorporated by ingesting or inhaling these radionuclides in air, water, and all types of food products. In addition, two cosmogenic radionuclides—tritium (hydrogen-3) and carbon-14—produce quantifiable internal doses. Table 3-30 lists estimated radiation doses from natural sources to individuals in the region of influence and other locations in the United States.

Effects of Radiation Exposure. The effect of radiation on people depends on the kind of radiation exposure (alpha and beta particles, and X-rays and gamma rays), the total amount of tissue exposed to radiation, and the duration of the exposure. The amount of radiant energy imparted to tissue from exposure to ionizing radiation is referred to as *absorbed dose*. The sum of the absorbed dose to each tissue, when multiplied by certain quality and weighting factors that take into account radiation quality and different sensitivities of the various tissues, is referred to as *effective dose equivalent* and is expressed in *rem*. The Code of Federal Regulations contains further discussion of DOE radiation protection standards and methods of dose assessment (10 CFR Part 835).

An individual can be exposed to radiation from outside or inside the body because radioactive materials can enter the body by ingestion or inhalation. External dose is different from internal dose in that it is delivered only during the actual time of exposure. An internal dose, however, continues to be delivered as long as the radioactive source is in the body (although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes usually decrease the *dose rate* with the passage of time).

TERMS USED IN RADIATION DOSE ASSESSMENT

Curie: A unit of radioactivity equal to 37 billion disintegrations per second; also a quantity of any nuclide or mixture of nuclides having 1 curie of radioactivity.

Picocurie per liter (or gram): A unit of concentration measure describing the amount of radioactivity (in picocuries) in a volume (or mass) of a given substance [typically, air or water (by volume) or soil (by mass)]. A picocurie is one one-trillionth of a curie.

Rad: The unit of absorbed radiation dose in terms of energy. One rad is equal to an absorbed dose of 100 ergs per gram.

Rem: The unit of effective dose equivalent from ionizing radiation to the human body. It is used to express the amount of radiation to which a person has been exposed. The effective dose equivalent in rem is equal to the absorbed dose in rad multiplied by quality and weighting factors that are necessary because biological effects can vary both by the type of radiation (even of the same deposited energy) and by the specific tissue exposed.

Total effective dose equivalent: Often generically referred to simply as dose, it is an expression of the radiation dose received by an individual from external radiation and from radionuclides internally deposited in the body. All doses presented in this document are in terms of total effective dose equivalent.

Latent cancer fatality: A death resulting from cancer that has been caused by exposure to ionizing radiation. There is typically a latent period between the time of radiation exposure and the time the cancer cells become active.

Table 3-30. Radiation exposure from natural sources (millirem per year).[a]

	Annual dose (effective dose equivalent)					
					Region of influence	
Source	U.S. average	Aiken[b]	Oak Ridge[c]	Las Vegas	Amargosa Valley	Beatty
Cosmic and cosmogenic	28	29	36	(d)	40	(d)
Terrestrial	28	24	51	89	56	150
Radon in homes (inhaled)[e]	200	200	200	200	200	200
In body	40	40	40	40	40	40
Totals[f]	***300***	***290***	***330***	***330***	***340***	***390***

a. Sources: DIRS 146592-Black and Townsend (1998, p. 4-31); DIRS 103208-DOE (1995, p. 4-211 and 4-394) DIRS 103207-DOE (1995, Figure 3-16); DIRS 101855-NCRP (1987, Section 2); DIRS 153135-DOE (1999, p. A-9).
b. Aiken, South Carolina, is the location of the DOE Savannah River Site.
c. Oak Ridge, Tennessee, is the location of the DOE Oak Ridge Reservation.
d. Included in the terrestrial source.
e. Value for radon is an average for the United States.
f. Totals might differ from sums due to rounding.

Radiation can cause a variety of adverse health effects in people. The following discussion is an overview of the method commonly used to estimate effects of radiation exposure; Appendix F contains more detailed information. At low doses, the most important adverse health effect for depicting the consequences of environmental and occupational radiation exposures (which are typically low doses) is the potential inducement of cancers that can lead to death in later years. This effect is referred to as *latent cancer fatalities* because the cancer can take years to develop and for death to occur, and might never actually be the cause of death.

The collective dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. This is referred to as a *population dose*. The total population dose received by the exposed population is measured in *person-rem*. For example, if 1,000 people each received a dose of 0.001 rem, the population dose would be 1.0 person-rem (1,000 persons multiplied by 0.001 rem equals 1.0 person-rem). The same population dose (1.0 person-rem) would result if 500 people each received a dose of 0.002 rem (500 persons multiplied by 0.002 rem equals 1 person-rem).

The factor used in this EIS to relate a dose to its potential effect is 0.0004 latent cancer fatality per person-rem for workers and 0.0005 latent cancer fatality per person-rem for individuals among the general population (DIRS 101856-NCRP 1993, p. 3). The latter factor is slightly higher because some individuals in the public, such as infants, might be more sensitive to radiation than workers. These risk factors have also been endorsed by the International Commission on Radiological Protection, Nuclear Regulatory Commission, and National Council on Radiation Protection and Measurements. The Environmental Protection Agency recently published an age-specific risk factor of 0.000575 latent cancer fatality per person-rem (DIRS 153733-EPA 2000, Table 7.3, p. 179), which is discussed in Appendix F. Both the Agency and DOE recognize that there are large uncertainties associated with these risk factors. As a consequence, DOE believes that the 15-percent difference in these risk factors (between 0.0005 and 0.000575) is well within other uncertainties and would provide little additional information to the decisionmaking process supported by this document. For these reasons, in its National Environmental Policy Act documents, DOE has continued to use risk factors recommended by the International Commission on Radiological Protection.

These concepts can be used to estimate the effects of exposing a population to radiation. For example, if 100,000 people were each exposed only to background radiation (0.3 rem per year), 15 latent cancer fatalities could occur as a result of 1 year of exposure (100,000 persons multiplied by 0.3 rem per year multiplied by 0.0005 latent cancer fatality per person-rem equals 15 latent cancer fatalities).

Calculations of the number of latent cancer fatalities associated with radiation exposure do not normally yield whole numbers and, especially in environmental applications, can yield numbers less than 1.0. For example, if 100,000 people were each exposed to a total dose of only 1 millirem (0.001 rem), the population dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 (100,000 persons multiplied by 0.001 rem multiplied by 0.0005 latent cancer fatality per person-rem equals 0.05 latent cancer fatality).

The *average* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people is 0.05. In most groups, nobody (zero people) would incur a latent cancer fatality from the 1-millirem dose each member would have received. In a small fraction of the groups, 1 latent fatal cancer would result; in exceptionally few groups, 2 or more latent fatal cancers would occur. The average number of deaths over all the groups would be 0.05 latent fatal cancer (just as the average of 0, 0, 0, and 1 is 0.25). The most likely outcome is no latent cancer fatalities in these different groups.

To aid in decisionmaking, DOE has applied these same concepts in estimating the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The probability of a latent cancer fatality corresponding to a single individual's exposure to 0.3 rem a year over a (presumed) 70-year lifetime is:

$$\begin{aligned}\text{Probability of a latent cancer fatality} \quad &= 1 \text{ person} \times 0.3 \text{ rem per year} \times 70 \text{ years} \\ &\quad \times 0.0005 \text{ latent cancer fatality per person-rem} \\ &= 0.011 \text{ probability of a latent cancer fatality.}\end{aligned}$$

Again, this should be interpreted in a statistical sense; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.1-percent chance that the individual would incur a latent fatal cancer. For comparison purposes, statistics published by the Centers for Disease Control indicate that during 1998, 24 percent of all deaths in the State of Nevada were attributable to cancer from all causes (DIRS 153066-Murphy 2000, p. 83).

3.1.8.2 Radiation Environment in the Yucca Mountain Region

Ambient radiation levels from cosmic and terrestrial sources at Yucca Mountain are higher than the U.S. average. The higher elevation at Yucca Mountain results in higher levels of cosmic radiation due to less shielding by the atmosphere. The U.S. average for cosmic, cosmogenic, and terrestrial radiation exposures is 56 millirem per year (Table 3-30). The exposures at the Yucca Mountain ridge and Yucca Mountain surface facilities are about 160 and 150 millirem per year, respectively. Moreover, there are higher amounts of naturally occurring radionuclides in the soil and parent rock of this region than in some other regions of the United States, which also results in higher radiation doses.

The surface environment, or soil, of Yucca Mountain contains the following naturally occurring radionuclides (DIRS 146183-CRWMS M&O 1996, all):

Radionuclide	Dry weight concentration (picocuries per gram)
Uranium-238	0.002 to 0.22
Radium-226	0.77 to 3.3
Thorium-232	0.17 to 0.92
Potassium-40	18 to 35

DOE measured external dose rates on the surface with thermoluminescent dosimeters at 64 to 127 millirem per year. This compares to an average annual dose from cosmic, cosmogenic, and terrestrial radiation in the Amargosa Valley of 96 millirem per year (Table 3-30).

With respect to the subsurface environment, the content of naturally occurring uranium and thorium in rock at Yucca Mountain has been measured at 2 to 6 and 15 to 35 milligrams per kilogram, respectively (DIRS 105946-Vaniman et al. 1996, Table 1-5; DIRS 155605-Bush, Bunker, and Spengler 1983, Table 1, pp. 4 to 7). The activity concentrations for uranium-238 are about 0.7 to 1.7 *picocurie* per gram, and for thorium-232 they are about 1.7 to 3.7 picocuries per gram. The activity concentrations of uranium and thorium decay products, including various isotopes of radium, should be in equilibrium in undisturbed rock and have the same activity concentration as the respective precursor radionuclide. The potassium content of the rock ranges from about 1 to 5 percent (DIRS 155605-Bush, Bunker, and Spengler 1983, Table 1, pp. 4 to 7). Because the natural abundance of radioactive potassium-40 is about 0.012 percent, the potassium-40 content of the rock ranges from about 1.4 to 5.9 milligrams per kilogram, an activity concentration of 10 to 41 picocuries per gram. Appendix F, Section F.1.1.6 discusses the range of background external radiation levels in the Exploratory Studies Facility. External exposure rates range from 0.014 to 0.038 millirem per hour and the median dose to a subsurface worker would be about 50 millirem per year.

The Yucca Mountain Project and the DOE Nevada Operations Office (in conjunction with the Environmental Protection Agency) conduct environmental surveillances around the Nevada Test Site. This monitoring has identified no radioactivity attributable to current operations at the Test Site. It did detect trace amounts of manmade radionuclides from worldwide nuclear testing in milk, game, and foods and in soil. Even though the monitoring has not detected ongoing releases to the environment related to the Test Site, DOE has made quantitative estimates of offsite doses from releases from past weapons testing activities at the Nevada Test Site (DIRS 155569-Townsend and Grossman 2000, pp. 7-1 to 7-4). DOE discusses estimates of radiation doses to the general population from past test site activities at the end of this section. Sources of ongoing releases at the Nevada Test Site include water containment ponds and contaminated soil resuspension. The estimated maximum annual radiation dose to a hypothetical individual in Springdale, Nevada [approximately 14 kilometers (9 miles) north of Beatty on U.S. 95], from airborne radioactivity is 0.12 millirem and 0.38 person-rem to the population within 80 kilometers (50 miles) of Nevada Test Site airborne emission sources. The maximum hypothetical-individual dose, which is about 1 percent of the 10-millirem-per-year dose limit that the Environmental Protection Agency established for a member of the public from emissions to the air from manmade sources (40 CFR Part 61), is conservative because data from offsite surveillance do not support doses of this magnitude.

Workers in the Exploratory Studies Facility can inhale naturally occurring radon-222 (a radioactive *noble* gas that is a decay product of naturally occurring uranium in rock) and its radioactive decay products. Radon concentration measurements during working hours, at a location representative of repository conditions, ranged from about 0.24 to 65 picocuries per liter (5th to 95th percentile), with a median concentration of about 13 to 17 picocuries per liter (DIRS 156114-Carl 2001, all). The median annual dose to Exploratory Studies Facility workers from inhalation of radon and decay products underground was estimated to be about 15 millirem, with an average of about 40 millirem and range from 0 to 180 millirem (5th to 95th percentile) (DIRS 156118-Gonzalez 2001, all). Appendix F, Section F.1.1.6, contains additional information on the estimated underground dose to *involved workers* from radon.

Workers in the Exploratory Studies Facility are also exposed to external gamma radiation from radon decay products and other naturally occurring radionuclides. Ambient radiation monitoring in this facility indicated a dose rate from background sources of radionuclides in the drift walls of about 0.014 to 0.038 millirem per hour, which would be about 50 millirem per year for a 2000-hour work year (see Appendix F, Section F.1.1.6).

Naturally occurring radon-222 and decay products are released from the Exploratory Studies Facility in the exhaust ventilation air. The estimated annual release of radon and decay products is about 80 curies. The estimated annual dose to an individual 20 kilometers (12 miles) south of the repository is less than 0.1 millirem. The estimated annual dose to the population within 80 kilometers (50 miles) is about 10 person-rem. These doses are small percentages of the dose from natural sources shown in Table 3-30. Appendix G contains additional information on the estimated releases of radon from the repository.

Effects from Past Nevada Test Site Weapons Testing. The history of the testing of nuclear weapons can be broadly divided into two eras, the era in which testing was predominantly performed above ground (1951 to 1961) and the era in which testing was performed predominantly underground (1961 to 1992). Since 1992, there has been a moratorium on nuclear testing. DOE described the activities at the Nevada Test Site in a previous NEPA document, the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DIRS 101811-DOE 1996, all).

Radiation doses to the population surrounding the Nevada Test Site have been the subject of several reports since the inception of the nuclear weapons testing program. For example, the National Council on Radiation Protection and Measurements published estimates of effective dose equivalents in its Publication 93 (DIRS 101855-NCRP 1987, all), in which it reported an average dose commitment to each individual in the United States from all weapons testing of approximately 250 millirem received up through 2000 with very little received thereafter from deposition in the body.

A more recent report prepared by the National Cancer Institute (DIRS 152469-Institute of Medicine and National Research Council 1999, all) evaluated doses to the thyroid glands of individuals from iodine-131 but did not estimate doses from other radionuclides. That report calculated thyroid doses for each series of nuclear weapons tests that had occurred and concluded that approximately 98 percent of the dose to the population due to iodine-131 deposition in the thyroid gland was from the atmospheric weapons testing, with approximately 2 percent due to underground testing.

The calculated average dose to the thyroid gland of individuals in Nevada ranged from 0.5 *rad* to 5.0 rad (which is close to 0.5 rem to 5.0 rem) for residents who lived in the area during all the tests. The

National Cancer Institute further estimated an exposed population of 213,000 for iodine-131 exposure. The majority of that exposed population resided outside the region of influence evaluated in this EIS at the time of their exposure.

As discussed by the National Council on Radiation Protection and Measurements (DIRS 101855-NCRP 1987, all), because of the time that has elapsed since the occurrence of atmospheric nuclear weapons testing, much of the radioactivity in the environment with the potential to cause appreciable radiation dose has undergone decay. Therefore, individuals with the greatest potential for appreciable radiation doses from weapons testing would be those who were born before the 1960s, with less potential for those born later.

3.1.8.3 Health-Related Mineral Issues Identified During Site Characterization

Certain minerals known to present a potential risk to worker health are present in the volcanic rocks at Yucca Mountain (DIRS 101779-DOE 1998, Volume 1, pp. 2-24 and 2-25). The risks are generally related to potential exposures caused by inhalation of airborne particulates (dust). Some of the minerals represent a hazard commonly associated with underground construction, whereas others are rare and less well known.

Crystalline silica (silicon dioxide) comes in several forms—among them quartz, tridymite, and cristobalite. Inhaling silica dust causes a disease called *silicosis* that damages an area of the lungs called the air sac (alveoli) (DIRS 103243-EPA 1996, all). The presence of silica dust in the alveoli causes a defensive reaction that results in the formation of scar tissue in the lungs. This scar tissue can reduce overall lung capacity.

DOE typically performs evaluations of exposure to crystalline silica at Yucca Mountain for cristobalite that encompass potential impacts from exposure to other forms of crystalline silica. The repository host rock has a cristobalite content ranging from 18 to 28 percent (DIRS 104523-CRWMS M&O 1999, p. 4-81). The American Conference of Governmental Industrial Hygienists has established Threshold Limit Values for various forms of crystalline silica (DIRS 103070-ACGIH 1999, p. 61). These limits are based on an 8-hour day and 40-hour week and, therefore, could be exceeded for a short period—as long as the average time spent by a worker is below the limit. The Threshold Limit Values for respirable cristobalite dust and quartz dust are 0.05 and 0.1 milligram per cubic meter, respectively. In addition, crystalline silica has been listed by the World Health Organization as a *carcinogen* (DIRS 100046-IARC 1997, p. 41).

Normal underground mechanical excavation produces dust when the rock is broken loose from the face. Dust is also generated when the broken rock is transferred to railcars or conveyors, or a storage pile. Dust can also be generated by wind erosion of excavated rock storage piles. Excavation activities during site characterization have caused exceedances of crystalline silica Threshold Limit Values at specific work locations. Workers at these locations were required to wear respirators. DOE will use the experience gained during Exploratory Studies Facility activities to design engineering controls to minimize future exposures.

Erionite is an uncommon zeolite mineral that the International Agency for Research on Cancer recognized as a human carcinogen in 1987; at Yucca Mountain, it occurs primarily in the basal vitrophyre of the Topopah Spring tuff and in isolated zones of the Tiva Canyon tuff (see Section 3.1.3). Even at low concentrations erionite is believed to be a potent carcinogen capable of causing mesothelioma, a form of lung cancer. As a result of its apparent carcinogenicity, erionite could pose a risk if encountered in quantity during underground construction, even with standard modern construction practices. Because erionite appears to be absent or rare at the proposed repository depth and location, most repository operations should not be affected. However, repository workers would take precautions (for example, dust suppression, air filters, personal protective gear) during construction when penetrating horizons in which erionite could occur, such as in the basal vitrophyre of the Topopah Spring tuff.

A number of other minerals present at Yucca Mountain might have associated health risks if prolonged exposures occur; however, there is no evidence suggesting a link to cancer. Therefore, the International Agency for Research on Cancer has ranked these substances not classifiable (DIRS 100046-IARC 1997, all). Some of the minerals identified and considered in establishing health and safety practices for potential repository operations include the zeolite group minerals mordenite (which is fibrous and similar in some respects to erionite), clinoptilolite, heulandite, and phillipsite. Because there is no known risk associated with the other zeolite minerals, and because they occur primarily in nonwelded units below the repository horizon, they probably do not represent a large risk. The measures implemented to mitigate risk from silica (for example, dust suppression, air filters, personal protective gear) should also protect workers from exposure to other minerals.

3.1.8.4 Industrial Health and Safety Impacts During Construction of the Exploratory Studies Facility

During Yucca Mountain site characterization activities, health and safety impacts to workers have resulted from common industrial hazards (such as tripping and falling). The categories of worker impacts include total *recordable* incidents, lost workdays, and fatalities. Recordable incidents or cases are occupational injuries or occupation-related illnesses that result in (1) a fatality, regardless of the time between the injury or the onset of the illness and death, (2) *lost workday cases* (nonfatal), and (3) incidents that result in the transfer of a worker to another job, termination of employment, medical treatment, loss of consciousness, or restriction of motion during work activities.

Site characterization activities at Yucca Mountain have had no involved worker fatalities. DOE has compiled statistics for the other types of health and safety impacts in accordance with the regulations of the Occupational Safety and Health Administration (29 CFR Part 1904) (see Appendix F, Section F.2). These statistics cover the 30-month period from the fourth quarter of 1994 through the first quarter of 1997. DOE selected this period because there was high onsite work activity in which the tunnel-boring machine was in operation in the Exploratory Studies Facility. DOE expects this condition to be characteristic of the types of activities that would occur during the construction of the surface facilities and the development of the emplacement drifts. Table 3-31 lists the industrial health and safety loss statistics for industry, general construction, general mining, and the Yucca Mountain site.

Table 3-31. Comparison of health and safety statistics for mining activities from the Bureau of Labor Statistics to those for Yucca Mountain during excavation of the Exploratory Studies Facility.[a]

Statistic	Total industry[b]	General construction[b]	General mining[b]	Yucca Mountain experience for involved workers[c]
Total recordable cases rate	7.1	9.5	5.9	6.8
Lost workday cases rate	3.3	4.4	3.7	4.8
Fatality rate	Not available	Not available	Not available	0.0[d]

a. Statistics based on 100 full-time equivalent work years or 200,000 worker hours.
b. Source: DIRS 148091-BLS (1998, all).
c. Source: Appendix F, Section F.2.
d. There have been no fatalities on the Yucca Mountain Project. However, the fatality rate obtained from the entire DOE CAIRS database for industrial activities is 0.0029 per 100 full-time equivalent work years.

3.1.9 NOISE AND VIBRATION

The region of influence for noise includes existing residences in the Yucca Mountain region and at the approximate boundary of the analyzed land withdrawal area. Noise comes from either natural or